F23, August (26026)

1)

Hvilket grundstof har følgende elektronkonfiguration i grundtilstanden?

Which element has the following ground-state electron configuration?

$1s^2 2s^2 2p^6 3s^2 3p^3$

P *
Na
Cu
Li
O

Suggested solution:
15 electrons in total in the ground state tells us that the element has atomic number 15, i.e phosphorous (P).

2)

En foton har en energi på 4,2 × 10^{-19} J. Hvilken type af elektromagnetisk stråling i det elektromagnetiske spektrum svarer det til?

A photon has an energy of 4.2 × 10^{-19} J. Which type of radiation in the electromagnetic spectrum is this corresponding to?

Synligt lys / *Visible light* *
Røntgenstråling / *X-ray*
Ultraviolet lys / *Ultraviolet*
Infrarød stråling / *Infrared*
Mikrobølger / *Microwave*

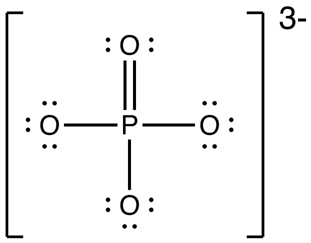
Suggested solution:

λ = hc / E = ((6.63 × 10^{-34} Js) × (3.00 × 10^{8} m/s)) / (4.2 × 10^{-19} J) = 4.74 × 10^{-7} m = 474 nm
Visible light, since it ranges from 400 (violet) to 700 nm (red)

3)

Hvilken af de følgende illustrationer er en gyldig Lewis-struktur for en fosfation (PO_4^{3-})?

Which of the following illustrations is a valid Lewis structure for the phosphate ion (PO_4^{3-})?



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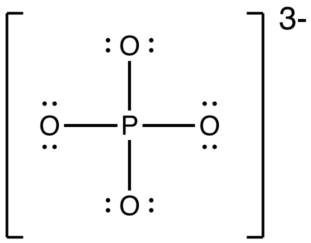
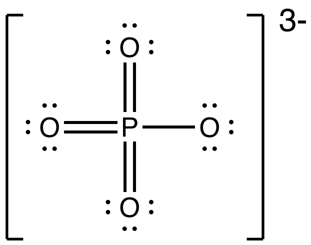
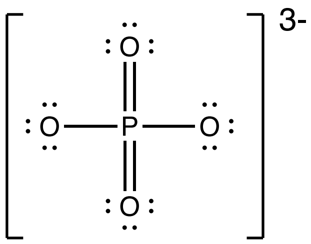
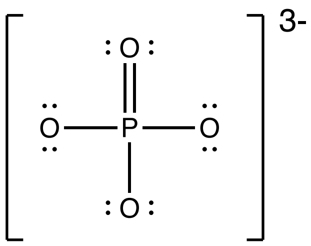








<u>Suggested solution:</u>

Follow principles for writing Lewis structures as described in section 9.6 (General Chemistry).

4)

Arranger følgende diatomiske forbindelser i rækkefølge efter stigende ionkarakter af bindingen: HCl, F_2, RbBr, CsI, LiI

Arrange the following diatomic compounds in order of increasing ionic character of the bond: HCl, F_2, RbBr, CsI, LiI

F_2 < HCl < LiI < CsI < RbBr *
HCl < LiI < CsI < RbBr < F_2
F_2 <RbBr < HCl < LiI < CsI
CsI < RbBr < F_2 < HCl < LiI
LiI < F_2 < RbBr < CsI < HCl

Suggested solution:
Electronegativity difference:

F_2: 0-0=0
HCl: 3.0-2.1=0.9
CsI: 2.5-0.7=1.8
LiI: 2.5-1.0=1.5
RbBr: 2.8-0.8=2.0

Hence: F_2 (0) < HCl (0.9) < LiI (1.5) < CsI (1.8) < RbBr (2.0)

5)

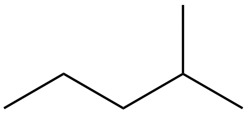
Angiv antallet af mulige strukturelle isomerer af C_6H_{14}.

Indicate the number of possible structural isomers of C_6H_{14}.

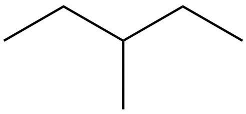
5 *
2
3
4
6

Suggested solution:

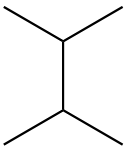
hexane



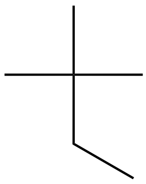
2-methylpentane



3-methylpentane



2,3-dimethylbutane



2,2-dimethylbutane

6)

Hvad er frysepunktet for en opløsning af 1% (w/w) NaCl i vand ved 1 atm., givet at K_f for vand er 1,86 °C/m, og van´t Hoff-faktoren for NaCl er 1,9?

What is the freezing point of a solution of 1% (w/w) NaCl in water at 1 atm., given that K_f for water is 1.86 °C/m and that the van´t Hoff factor for NaCl is 1.9?

- 0,61 °C *
- 2,79 °C
- 1,34 °C
- 0,30 °C
- 4,21 °C

Suggested solution:

Assume 100 g of solution, i.e. 1 g of NaCl in 99 g of water.
n (NaCl) = (1 g) / (58.44 g/mol) = 0.01711 mol
molality = 0.01711 mol / 0.099 kg = 0.1728 mol/kg
$\Delta T = i \times K_f \times m = 1.9 \times 1.86$ °C/m $\times 0.1728$ m = 0.61 °C
$T_f = T_f^0 - \Delta T = 0$ °C - 0.61 °C = -0.61 °C

7)

Lithium krystalliserer i en kubisk rumcentreret (bcc) struktur. Hvor mange enhedsceller er der i 1,0 g lithium?

Lithium crystallizes in a body-centered cubic (bcc) structure. How many unit cells are present in 1.0 g lithium?

$4{,}33 \times 10^{22}$ *
$2{,}17 \times 10^{22}$
$1{,}08 \times 10^{22}$
$8{,}68 \times 10^{22}$
$1{,}74 \times 10^{22}$

<u>Suggested solution:</u>
M(Li) = 6.941 g/mol
n(Li) = 1.0 g / (6.941 g/mol) = 0.1441 mol
1 mol = 6.022×10^{23} atoms
Number of Li atoms = 0.1441 mol × 6.022×10^{23} atoms / mol = 8.67598×10^{22} atoms
bcc structure implies 2 atoms per unit cell
Total number of unit cells = Number of Li atoms / Number of atoms per unit cell
$8.67598 \times 10^{22} / 2 = 4.33 \times 10^{22}$

8)

Beregn aktiveringsenergien for en reaktion, der finder sted ved 298 K, givet at reaktionens hastighedskonstant er 3,18 × 10^{-4} s^{-1}, og at frekvensfaktoren er 5,11 × 10^{13}.

Calculate the activation energy of a reaction which takes place at 298 K, given that the rate constant of the reaction is 3.18 × 10^{-4} s^{-1} *and that the frequency factor is 5.11 ×* 10^{13}.

98 kJ/mol *
51 kJ/mol
153 kJ/mol
161 kJ/mol
198 kJ/mol

Suggested solution:
Re-arranging the Arrhenius equation (in logarithmic form)
$\ln(k) = \ln(A) – E_a/RT$
$E_a = (\ln(A) – \ln(k)) \times RT$
$E_a = ((\ln 5.11 \times 10^{13}) – (\ln 3.18 \times 10^{-4})) \times (8.31 \times 298)$ J /mol = 98109 J/mol = 98 kJ/mol

9)

For reaktionen nedenfor er ligevægtskoncentrationerne $[N_2] = 8{,}5 \times 10^{-1}$ mol/L, $[H_2] = 3{,}1 \times 10^{-3}$ mol/L og $[NH_3] = 3{,}1 \times 10^{-2}$ mol/L ved en bestemt temperatur og tryk. Bestem ligevægtskonstanten.

N_2 (g) + $3H_2$ (g) ⇋ $2NH_3$ (g)

For the reaction below, the equilibrium concentrations are $[N_2] = 8.5 \times 10^{-1}$ mol/L, $[H_2] = 3.1 \times 10^{-3}$ mol/L, $[NH_3] = 3.1 \times 10^{-2}$ mol/L at a certain temperature and pressure. Determine the equilibrium constant.

N_2 (g) + $3H_2$ (g) ⇋ $2NH_3$ (g)

$3{,}8 \times 10^4$ *
$1{,}2 \times 10^1$
$8{,}5 \times 10^{-2}$
$2{,}6 \times 10^{-5}$
$2{,}4 \times 10^{-11}$

Suggested solution:

$K = [NH_3]^2 / ([N_2] \times [H_2]^3) = (3.1 \times 10^{-2})^2 / ((8.5 \times 10^{-1}) \times (3.1 \times 10^{-3})^3) = 37951$

10)

Nitrogen kan fremstilles ved at lede gasformig ammoniak over fast kobber(II)oxid ved høj temperatur. De andre produkter af reaktionen er fast kobber og vanddamp. Hvis en prøve indeholdende 18,1 g NH_3 reagerer med 90,4 g CuO, hvad er det maksimale udbytte af N_2?

Nitrogen gas can be prepared by passing gaseous ammonia over solid copper(II) oxide at high temperature. The other products of the reaction are solid copper and water vapor. If a sample containing 18.1 g of NH_3 is reacted with 90.4 g of CuO, what is the maximum yield of N_2?

10,6 g *
29,7 g
31,9 g
14,8 g
9,9 g

Suggested solution:
Balanced equation:
$2NH_3$ (g) + 3CuO (s) ⇋ N_2 (g) + 3Cu (s) + $3H_2O$ (g)
n(NH_3) = (18.1 g) / (17.03 g/mol) = 1.06 mol
n(CuO) = (90.4 g) / (79.55 g/mol) = 1.14 mol
According to reaction stoichiometry, CuO is the limiting reagent (1.59 mol CuO would be needed for complete reaction)
CuO / N_2 = 1/3
Maximum yield of N_2 = 1.14 / 3 mol = 0.380 mol
m(N_2) = 0.380 mol × 28.0 g/mol = 10.6 g

11)

Beregn massen af fast NaCl, der skal tilsættes til 1,50 L af en 0,100 M $AgNO_3$-opløsning for at udfælde Ag^+-ionerne som AgCl (s).

Calculate the mass of solid NaCl that must be added to 1.50 L of a 0.100 M $AgNO_3$ solution to precipitate the Ag^+ ions as AgCl (s).

8,77 g *
5,85 g
25,5 g
17,0 g
4,38 g

Suggested solution:

Ag^+ (aq.) + Cl^- (aq.) ⇋ AgCl (s)
$n(Ag^+)$ = 1.5 L × 0.100 mol/L = 0.150 mol
$n(Ag^+)/n(Cl^-)$ = 1/1
m(NaCl) = 0.150 mol × 58.45 g/mol = 8.77 g

12)

En motor forbruger 5,0 g nitromethan (CH_3NO_2) pr. minut ved forbrænding ifølge reaktionen $4CH_3NO_2 + 5O_2 \leftrightharpoons 4CO_2 + 6H_2O + 4NO$. Hvad er den mindste volumetriske luftstrøm (25 °C, 1 atm.), der skal tilføres for fuldstændig forbrænding af nitromethanen, forudsat at O_2-partialtrykket i luft er 0,2 atm., og at gasserne kan beskrives som ideelle gasser?

An engine consumes 5.0 g of nitromethane (CH_3NO_2) per minute through combustion according to the reaction $4CH_3NO_2 + 5O_2 \leftrightharpoons 4CO_2 + 6H_2O + 4NO$. What is the minimum volumetric air flow (25 °C, 1 atm.) that need to be supplied for complete combustion of the nitromethane, assuming that the O_2 partial pressure in air is 0.2 atm and that the gasses can be described as ideal gasses?

12,5 L/min *
3,1 L/min
20,3 L/min
1,1 L/min
7,9 L/min

Suggested solution:

Nitromethane consumption:
$n(CH_3NO_2) = (5.0 \text{ g/min}) / (61.04 \text{ g/mol}) = 0.08195 \text{ mol/min}$
$n(CH_3NO_2)/n(O_2) = 4/5$
$n(O_2) = 0.10244 \text{ mol/min}$
$V(O_2) = nRT/P = (0.10244 \text{ mol/min} \times 0.0821 \text{ L} \times \text{atm. K}^{-1} \text{ mol}^{-1} \times 298 \text{ K}) / (1 \text{ atm}) = 2.506 \text{ L/min}$

Dalton´s law of partial pressures:
$p(O_2) = 0.2 \text{ atm} \rightarrow 20 \text{ vol.\% } O_2$
Minimum air flow = 5 × 2.506 L/min = 12.53 L/min

13)

En prøve af metangas med et volumen på 2,80 L ved 25 °C og 1,65 atm. blev blandet med en prøve af oxygengas med et volumen på 35,0 L ved 31 °C og 1,25 atm. Blandingen blev derefter antændt for at danne kuldioxid og vanddamp. Beregn mængden af dannet CO_2 ved et tryk på 2,50 atm og en temperatur på 125 °C.

A sample of methane gas having a volume of 2.80 L at 25 °C and 1.65 atm. was mixed with a sample of oxygen gas having a volume of 35.0 L at 31 °C and 1.25 atm. The mixture was then ignited to form carbon dioxide and water vapor. Calculate the volume of CO_2 formed at a pressure of 2.50 atm and a temperature of 125 °C.

2,5 L *
22,9 L
1,8 L
6,2 L
37,8 L

Suggested solution:
Balanced equation:
CH_4 (g) + $2O_2$ (g) ⇋ CO_2 (g) + $2H_2O$ (g)
$n(CH_4)$ = PV/RT = 0.189 mol
$n(O_2)$ = PV/RT = 1.75 mol
From the balanced reaction we see that O_2 is in excess, and that CH_4 is the limiting reagent.
$n(CO_2)$ = 0.189 mol
$V(CO_2)$ = ((0.189 mol) × (0.08206 (L atm) / (K mol)) × 398 K) / (2.50 atm) = 2.47 L

14)

Standardentalpiændringen ved 298 K for reaktionerne mellem grafit og brint for dannelse af 1 mol ethen og ethan er:

2C (graphite) + $2H_2$ (g) ⇆ C_2H_4 (g) ΔH^0_{rxn} = +52,5 kJ/mol
2C (graphite) + $3H_2$ (g) ⇆ C_2H_6 (g) ΔH^0_{rxn} = -83,8 kJ/mol

Beregn standardentalpiændringen for hydrogeneringen af ethen til ethan ved 298 K ifølge reaktionen C_2H_4 (g) + H_2 (g) ⇆ C_2H_6 (g).

The standard enthalpy change at 298 K for the reactions of graphite and hydrogen gas to form 1 mol of ethene and ethane are:

2C (graphite) + $2H_2$ (g) ⇆ C_2H_4 (g) ΔH^0_{rxn} = +52.5 kJ/mol
2C (graphite) + $3H_2$ (g) ⇆ C_2H_6 (g) ΔH^0_{rxn} = -83.8 kJ/mol

Calculate the standard enthalpy change for the hydrogenation of ethene to ethane at 298 K, according to the reaction C_2H_4 (g) + H_2 (g) ⇆ C_2H_6 (g).

-136,3 kJ/mol *
136,3 kJ/mol
-31,3 kJ/mol
31,3 kJ/mol
-68,2 kJ/mol

Suggested solution:
Manipulate the equations to get the reaction of interest:

2C (graphite) + $3H_2$ (g) ⇆ C_2H_6 (g) ΔH^0_{rxn} = -83.8 kJ/mol
C_2H_4 (g) ⇆ 2C (graphite) + $2H_2$ (g) ΔH^0_{rxn} = -52.5 kJ/mol

C_2H_4 (g) + H_2 (g) ⇆ C_2H_6 (g) ΔH^0_{rxn} = -136.3 kJ/mol

15)

Beregn ligevægtskonstanten for følgende redoxreaktion ved 25 °C:

$S_4O_6^{2-}$ (aq) + $2Cr^{2+}$ (aq) ⇋ $2Cr^{3+}$ (aq) + $2S_2O_3^{2-}$ (aq)

$S_4O_6^{2-} + 2e^- \leftrightharpoons 2S_2O_3^{2-}$ E^0 = 0,17 V
$Cr^{3+} + 2e^- \leftrightharpoons Cr^{2+}$ E^0 = -0,50 V

Calculate the equilibrium constant for the following redox reaction at 25 °C:

$S_4O_6^{2-}$ (aq) + $2Cr^{2+}$ (aq) ⇋ $2Cr^{3+}$ (aq) + $2S_2O_3^{2-}$ (aq)

$S_4O_6^{2-} + 2e^- \leftrightharpoons 2S_2O_3^{2-}$ *E^0 = 0.17 V*
$Cr^{3+} + e^- \leftrightharpoons Cr^{2+}$ *E^0 = -0.50 V*

5×10^{22} *
2×10^{11}
7×10^{-12}
3
4×10^{39}

Suggested solution:
$E^0_{cell} = E^0_{red} - E^0_{ox}$ = 0.17 V – (-0.50 V) = 0.67 V
$\log(K) = nE^0_{cell} / 0.0591 = (2 \times 0.67) / 0.0591 = 22.673$
$K = 10^{22.673} = 4.7 \times 10^{22}$

16)

Syredissociationskonstanten for hypochlorsyrling (HOCl) i vand er 3,5 × 10^{-8}. Beregn pH-værdien af en 0,500 M vandig opløsning af hypochlorsyrling.

The acid dissociation constant of hypochlorous acid (HOCl) in water is 3.5 × 10^{-8}. Calculate the pH of a 0.500 M aqueous solution of hypochlorous acid.

3,9 *
4,2
6,5
2,0
1,1

<u>Suggested solution:</u>

$$HOCl\ (aq.) + H_2O\ (l) \rightleftarrows OCl^-\ (aq.) + H_3O^+\ (aq.)$$

Initial	0.500	0	0
Change	-x	+x	+x
Eq.	0.500-x	x	x

HOCl significantly stronger acid than H_2O, hence
$K_a = 3.5 \times 10^{-8} = [OCl^-][H_3O^+] / [HOCl]$

Assume x<<0.500 and:

$3.5 \times 10^{-8} = x^2 / (0.500-x) = x^2 / 0.500$
$x^2 = 0.500 \times 3.5 \times 10^{-8}$
$x = 1.32 \times 10^{-4}$ or -1.32×10^{-4} (physically impossible)

Test approximation:
1.32×10^{-4} M / 0.500 M = 0.03% (approx. ok)

At equilibrium:
$[H_3O^+] = 1.32 \times 10^{-4}$ M
pH = -log 1.32×10^{-4} = 3.87

17)

Hydrogencyanid (HCN) er en svag syre med $K_a = 6,2 \times 10^{-10}$ i vand. En 100 mL prøve af en 50 mM HCN vandig opløsning titreres med en vandig opløsning af 0,100 M NaOH. Beregn pH af prøveopløsningen ved ækvivalenspunktet.

Hydrogen cyanide (HCN) is a weak acid with $K_a = 6.2 \times 10^{-10}$ in water. A 100 mL sample of a 50 mM HCN aqueous solution is titrated with an aqueous solution of 0.100 M NaOH. Calculate the pH of the sample solution at the equivalence point.

10,9 *
9,5
12,1
8,7
7,8

Suggested solution:

	HCN (aq.) +	NaOH (aq.)	⇄	NaCN (aq.) + H_2O
Initial (mol)	5.00×10^{-3}	5.00×10^{-3}		0 mmol
Change (mol)	$- 5.00 \times 10^{-3}$	$- 5.00 \times 10^{-3}$		$+ 5.00 \times 10^{-3}$
Final (mol)	0	0		$+ 5.00 \times 10^{-3}$

Equivalence point reached when n(HCN) = n(NaOH), i.e. after addition of

V (NaOH) = n/C = (5.00×10^{-3} mol) / 0.100 mol/L = 50 mL

Total volume is (100 + 50 mL) = 150 mL

[NaCN] = (5.00×10^{-3} mol) / 0.150 L = 0.0333 M

Calculate pH

	CN^- (aq.) +	H_2O (l) ⇄	HCN (aq.) +	OH^- (aq.)
Initial	0.0333		0	0
Change	-x		+x	+x
Eq.	0.0333-x		x	x

$K_b =$ [NaCN] $[OH^-]$ / $[CN^-]$
$K_b = K_w / K_a = 1.612 \times 10^{-5}$

Because K_b is very small and the initial concentration of the base is large, we can apply the approximation 0.0333 – x = 0.0333

$1.612 \times 10^{-5} = x^2 / (0.0333 - x)$

$x = [OH^-] = 7.3267 \times 10^{-4}$ M

pOH = 3.135

pH = 14 - pOH = 10.86

18)

Angiv de støkiometriske koefficienter (a-f), som afstemmer redoxreaktionen nedenfor i en vandig, sur opløsning.

Indicate which set of stoichiometric coefficients (a-f) that balances the redox reaction below in aqueous acidic environment.

a H^+ (aq.) + b $Cr_2O_7^{2-}$ (aq.) + c C_2H_5OH (l) ⇋ d Cr^{3+} + e CO_2 (g) + f H_2O (l)

a = 16, b = 2, c = 1, d = 4, e = 2, f = 11 *
a = 12, b = 2, c = 2, d = 7, e = 3, f = 5
a = 8, b = 1, c = 1, d = 2, e = 2, f = 8
a = 4, b = 1, c = 1, d = 2, e = 2, f = 14
a = 20, b = 2, c = 1, d = 4, e = 2, f = 10

Suggested solution:

16 H^+ (aq.) + ***2*** $Cr_2O_7^{2-}$ (aq.) + ***1*** C_2H_5OH (l) ⇋ ***4*** Cr^{3+} + ***2*** CO_2 (g) + ***11*** H_2O (l)

19)

Angiv antallet af uparrede elektroner i henholdsvis $[Fe(CN)_6]^{3-}$ og $[FeCl_6]^{4-}$ kompleks-ioner, begge med oktaederisk symmetri.

Find the number of un-paired electrons in $[Fe(CN)_6]^{3-}$ and $[FeCl_6]^{4-}$, respectively, both with octahedral symmetry.

1, 4 *
5, 6
4, 2
2, 1
1, 2

Suggested solution:

$[Fe(CN)_6]^{3-}$
Fe(III) electron configuration [Ar] $3d^5$
CN^- strong field ligand

↑↓	↑↓	↑

$[FeCl_6]^{4-}$
Fe(II) electron configuration [Ar] $3d^6$
Cl^- weak field ligand

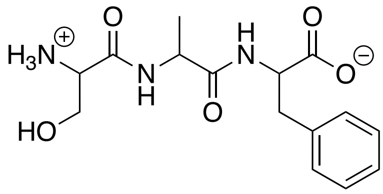
↑	↑

↑↓	↑	↑

20)

Hvilken kemisk struktur svarer til et tripeptid, der kan dannes af aminosyrerne serin, alanin og phenylalanin?

Which chemical structure corresponds to a tripeptide derived from the amino acids serine, alanine and phenylalanine?



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